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Tittel:
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Title: Subsea control system

Technical field

The present invention relates to the field of subsea control systems.

More particularly, the invention relates to a control system for controlling a number of devices for a subsea installation such as a Christmas tree or a manifold comprising a subsea control module, at least one device controlled by the control module and a cable connecting the device with the control module.

Background of the invention

A standard subsea installation comprises a mixture of hydraulically and electrically operated devices. The hydraulic devices are normally actuators for the operation of valves on the installation. The actuators may be controlled by electrically operated pilot valves housed in a control module located at or near the well, the pilot valves directing the supply of fluid to each actuator, as dictated by the need for operation. Such a system is therefore called an electro-hydraulic system. In addition, injection valves for supplying chemicals may be needed and such valves are usually electric solenoid operated valves. Other devices are electrical of nature, such as sensors for monitoring various parameters in system, such as pressure and temperature, flow rates and sand and scale detectors. These usually communicate with the control system module via a dedicated cable, each sensor being connected separately to the control module, for receiving and transmitting signals and, in some cases electric power.

It has been proposed to use directly electrically operated valves, using electric motors, as this will be simpler and eliminate the need for large and costly hydraulic actuators and the use of pilot valves, since the actuators can be directly controlled. However, an all electric system necessitates better monitoring of the devices. and sensor for sensing the state of other devices, e.g. actuators. If the actuator is wholly electric it may also be necessary to monitor the position of the valve spindle and the number of rotations of the electric motor.

The standard control module used in today's systems is housed in a container filled with an inert gas such as Nitrogen and pressurised at 1 bar to protect the electronics of the system. It contains the electronics for receiving signals from the sensor devices and for transmitting signals to a control station at a production vessel (FPSO). All the electrical pilot valves are also housed in the control module. The supply line for hydraulic and chemical fluids are connected to the control module with lines extending therefrom to the hydraulic actuators and the chemical injection points as needed. This system is very inflexible, It must be decided beforehand for example how many pilot valves will be needed. If more pilot valves will be needed then either the control module must be pulled up and exchanged with a new and larger. Usually the control module will be larger than needed in case the system

needs to be extended, One problem concerns the flexibility of such a system and the need for adding extra devices as necessary, without dismantling or otherwise changing the system.. When new devices are added the whole system must be shut down and reconfigured. If new sensors are needed the electronics must be reprogrammed before they can be used.

In other fields such as in the computer field local area networks (LAN) are well known and state of the art. For example, in a TCP/IP computer system each computer has a unique address such that a computer can always be identified on the network. Such systems consist of a controller unit with a micro processor, a bus controller, a memory unit and an input signal controller. Examples of such systems are described in WO 9914643 and WO 02054163, and in US Patent No. 5,941,966.

Summary of the invention

According to the invention there is provided a control system for a subsea installation comprising at least one actuator and at least one sensor comprising a single backbone bus cable carrying power and signal cables to the various parts of the installation.

The actuators may be hydraulic or electric actuators.

According to the invention, electrical connectors are provide throughout the system, so that a variety of devices, such as motors, sensors, can be connected anywhere to the backbone bus.

Several additional devices can be connected at a location point by providing the location point with a router.

It is an abject of the invention to provide a control system that is wholly electric in nature and uses addressing technology to control any number of devices.

It is also an object of the invention to provide a control system that is flexible and that can be extended or added upon indefinitely.

The control system according to the invention allows devices to be installed as necessary, thereby reducing the need for upfront expenditure. With batteries, sensors and actuators all on the same distribution harness, they can be independently retrieved and separately repairable.

The features of the present invention are set forth in the appended claims.

Brief description of the drawings

The invention will now be described with reference to the accompanying drawings where

Fig. 1 is a drawing of a Christmas tree according to the invention.

Fig. 2 is a schematic drawing of bus connection elements in a control system according to the invention,

Fig. 3 is a schematic drawing showing the system according to the invention,

Fig. 4 is a drawing of an electro-hydraulic control pod,

Fig. 5 is a schematic block diagram illustrating a control module.

Detailed description of the invention

Fig. 1 shows a typical installation 1 located on the seabed 2 where the control system according to the invention may find use. In this example and as shown on the figure the installation 1 is a Christmas tree 11 mounted on a wellhead 12, the wellhead being the top part of a well that extends down into the ground below the seabed 2. The Christmas tree has a number of actuators 13 for the actuation of valves (not shown). A control module 14 is attached to the Christmas tree, the control module housing the electronic equipment for receiving signals from and transmitting signals and power to the actuators 13. A cable 15 extends from the control module to the actuator. Other equipment, such as sensors, is also connected to the control module. A hydro acoustic communication unit 16 is attached to the Christmas tree and is connected to the control module 14 with a cable 17. The communication unit 16 also has an antenna 18. The control module houses an intelligent processor that controls the electronics in the system and handles communication signals both within the system and from the outside. The control module receives instructions and power through a cable 32 that is connected to a remote source. In a preferred embodiment the necessary electric power is being provided by a battery unit 34 installed in the control module.

The Christmas tree may include an ROV panel to allow manual actuation of the valves as is well known in the art. Each actuator is preferably a self-contained module that can be retrieved to the surface for repair or replacement. The actuation module is typically connected to the valve with a standard API ROV interface, enabling the valve to be operated manually by ROV even when the actuating module is removed.

Other installations where the invention can be useful includes, but not limited to, manifolds, subsea processing systems, workover controls or any system where a number of controllable devices are in use.

Fig. 2 is a schematic drawing that shows bus connection elements for use in the system according to the invention. The control system comprises a number of standard parts that can be assembled together to form the installation. At the heart

of the system there is one or more central control modules preferably located on or near the subsea installation but it may also be located a distance away on a separate installation.

The system has the following standard parts:

A simple cable 40 which is a cable preferably of fixed length for easier manufacture. The cable has male electrical connectors 44 at each end. The type 1 cable consists of a power and a signal line.

A harness cable 70 having a male connector 44 at one end, a splitter 78 in the middle that divides the cable into a number of sub cables, each with a male connector 44 at its end. The cable carries both power and signal lines. At the end of the sub cable various sensors or actuators can be attached, as shown in the lower left of the drawing.

A three-way junction box 50 having three in/out points 51, 52, 53, each with a female connector.

A three-way junction box 54, also having three in/out points, with a modem incorporated into the box and connected to one of the in/out points.

A teo-way junction box being a simple extension box with two in/out points, each with a female connector.

A termination junction box 42.

An electro-hydraulic pod 80. The electro-hydraulic pod 80 includes a number of pilot valves (not shown). A hydraulic supply line 82 is connected to one side of the pod. At the other side of the pod the hydraulic lines terminates in female hydraulic couplings. An MQC (Multiple Quick Connectors) plate having the same number of male couplings can be attached to the pod simultaneously connecting all couplers together. This is well known in the art and allows the pod to be retrieved more easily. The hydraulic lines from the MQC plate extends to hydraulic actuators (shown in outline). In the example the pod has 6 pilot valves and 6 lines to control 6 hydraulic actuators. This corresponds to the need of a typical Christmas tree with master main and wing valves, annulus master and wing valves, a crossover valve and a choke. The number of pilot valves can of course be more or less than six, depending upon the need for hydraulic actuators. An in/out point 81 allows the cable 40 to be connected with the pod to contriol the pilot valves.

It is preferred to locate the male connectors on the cables, but the cables may instead have female instead of male electrical connectors, the junction boxes having the corresponding male connectors

The system also comprises functional devices such as a control module, sensors, valves etc., as will be explained below.

Fig. 3 shows a typical subsea installation schematics according to the invention. A backbone cable is made up of a number n of type 1 cable units 40a, 40b, 40c, and so on.

The first cable unit 40a is connected to the control module 14. Each cable unit is connected to another cable unit by the three-way electrical junction box 50a, 50b and so on. If there is no need for a junction box with a branch (i.e. a three-legged junction box) to a functional device such as a sensor, a valve or a pod at a particular location, an extension junction box can be used instead. This allows insertion of a junction box later, if it becomes necessary to add such a functional device to the system The distal end of the last cable unit is connected to the termination box 42. However, it should be noted that all devices have electronics to enable them to function as terminations. It is therefore not necessary to have termination boxes at the end of the backbone cable as it can be terminated with a functional device instead. This allows the cable to be "daisy-chained" throughout the installation and forming the backbone. If at a later date it will be necessary to extend the system the termination can be replaced by a junction box and new cables added as needed.

In fig. 3 there is shown a pressure/transmitter sensor 62 connected to the backbone via cable 40. Another sensor, for example a flowmeter 64 is likewise connected to the backbone via cable 40. A number of electrically powered devices, for example solenoid valves 65, 66, 67, 68 are connected to the backbone with cable 70. A pod 80 is connected to the backbone via cable 60.

Fig. 3 also shows an example of a satellite extension. Another installation located at some distance away from the main installation can be connected with an extension cable 90. The larger step out distance makes it necessary to install a repeater or a modem to allow signals to travel a larger distance. The far end of cable 90 is connected to another modem junction box. If it is decided to have another installation this can easily be connected into the main installation by removing the termination and instead install the junction box 54.

The junction box 54 includes a modem in the leg. The modem is connected to a step-out cable that can extend a considerable distance from the main installation to another installation. There the cable is connected to another junction box 56, similar to the junction box 54, that also includes a modem. This junction box 56 forms the start of a new backbone cable, similar to the one above.

The power for running the electrical devices is preferable one or more batteries housed in the control module. However, power may instead be supplied through a

umbilical from a remote location. The batteries may, instead of being housed in the control module, be independently retrievable units connected to the backbone in the same manner as described above.

Fig. 4 is a schematic drawing showing the principle of connecting each device to the backbone.

In the schematic block diagram of fig. 4, a system according to the invention is illustrated. The system comprises the peripheral units (actuators, sensors, etc.), control bus, power supply line, and a programmable controller module. Each element is connected to the control bus 33 and supply line 34. As described above it is preferred to terminate the cable at a termination box. However, the control bus may be arranged as a loop, which begins and terminates in the control module 30.

The peripheral units include a communication unit that is suited to communicate according to the chosen protocol on the control bus (typical CAN bus). The controller unit may comprise a microprocessor or other data processing arrangement.. In case a CAN-bus is used, the bus controller is a CAN-bus controller and the bus driver is a CAN-bus driver. The memory unit may comprise of RAM, Programmable Read Only Memory (PROM), EPROM, EEPROM etc. Clearly, other bus types can be employed. Preferably the memory unit is reprogrammable and able to download new program instructions from a remote location for upgrading and/or extension of the system.

When an action is initiated by the controller unit, the controller generates a message telegram including the unique identifier for the unit to respond and transmits on the bus. The peripheral module scans the bus for messages having its address. The peripheral unit will, upon reception of the message having the specific identifier, acknowledge the message and respond according to the command. When the command is successfully completed a new message command is issues by the peripheral unit to report the status upon completion of the command. This message is then acknowledged by the controller unit, and the control sequence is completed.

Fig. 5 is a schematic block diagram futher illustrating a control module.

For illustration, only the control module 14 is shown. Other possible control modules included in the system are in principle identical to the control module 14.

The control module 14 comprises a controller 301 and a battery 303.

In one embodiment of the invention, the controller 301 and the battery 303 may be disconnectable during operation, In another embodiment the controller 301 and the battery 303 are permanently embedded in one unit 14.

The controller 301 (indicated by dotted line) is based on regular processor bus architecture, basically comprising an internal bus 302, connected to a microprocessor 304 and a memory 312. The memory 312 comprises program code and data, preferably held in a non-volatile memory such as Flash or EPROM and in a volatile memory such as RAM, respectively.

The bus 302 is further connected to a process interface adapter 306, in particular a CAN bus adapter.

The CAN bus adapter comprises a interface between the internal bus and the CAN bus, providing input/output operability between the processor and the physical processes in the subsea system.

In particular, the CAN bus adapter 306 comprises input circuits for the sensor input provided to the sensor input, and output circuits for providing appropriate actuator output signals,

The communication adapter 308 comprises input/output circuits providing two-way communication between the internal bus 302 and a remote station.

The bus 302 is further connected to a timer device.

The control module 14 further comprises a rechargeable battery 303. The battery provides electrical energy to the operation of the internal components of the control module, as well as the necessary effect needed for the control signals fed to the valve actuators. Also, the sensors are provided with electrical energy from the battery 303

The battery 303 may normally be charged by power transferred from the remote station. In addition or alternatively, a local power generator (not illustrated) may be employed as the primary energy source.

The control module has a programmable processor and is arranged to receive new software downloaded from the remote control station through the communication cable and the communication adapter 308. This allows the control module to be dynamic and to be updated to reflect changes, such as for example new sensors and new actuators.

CLAIMS

1. A control system for controlling a plurality of devices in a subsea installation connected to a common bus, comprising:
a command unit comprising a programmable device, a bus controller, a bus driver, a memory unit, a signal controller and a power controller,
a backbone cable extending through the system, the cable comprising a power cable and a signal cable and defining the common bus,
each device having an electronic unit, the unit comprising means for sending and receiving messages from the command unit for controlling and/or reading the device,
at least one input member and at least one output member interconnected through said common bus, each input or output member having a unique address and each device having a unique identity, that can be addressed through the bus.

2. A subsea control system according to claim 5 wherein the bus is a CAN bus.

3. A subsea control system according to claim 1 wherein the bus comprises terminal connectors for connecting a device to the bus.

4. A subsea control system according to claim 1 comprising a battery.

5. A subsea control system according to claim 1 comprising a modem.

6. A subsea control system according to claim 1 comprising an electro-hydraulic pod.

7. A subsea control system according to claim 1, wherein the operable device is an actuator for operating a valve between open and closed positions, the actuator comprising at least an electric motor and gearbox, a control unit for receiving signals from the central unit and power from a battery for controlling the actuator.

8. A subsea control system according to claim 1 wherein the operable device is a sensor.

9. A subsea control system according to claim 3 wherein the operable device is a pilot valve

10. A control system for controlling a plurality of devices in a subsea installation connected to at least one common bus, comprising:
a command unit comprising a programmable device, a bus controller, a bus driver, a memory unit, a signal controller and a power controller,
a backbone cable extending through the system, the cable comprising a power cable and a signal cable defining the common bus,
each device having an electronic unit, the unit comprising means for sending and receiving messages from the command unit for controlling and/or reading the device,
each device being removable connected to the backbone cable.

11. A control system according to claim 10 wherein the backbone cable comprises a number of cables, each connected end to end with electrical junctions.

12. A control system according to claim 10 wherein the junction box is two-way.

13. A control system according to claim 10 wherein the junction box is three-way.

14. A control system according to claim 10 wherein the junction box comprises a modem.

15. A control system according to claim 14 wherein the modem is connected to another modem located at a remote distance..

16. A control system according to claim 15 wherein the remote modem is a part of another control system, such that the remote system can be controlled from the command module..

17. A control system for controlling a plurality of devices in a subsea installation, comprising:
a command unit comprising a programmable device, a bus controller, a bus driver, a memory unit, a signal controller and a power controller,
a backbone cable extending through the system, the cable comprising a power cable and a signal cable defining the common bus,
each device having an electronic unit, the unit comprising means for sending and receiving messages from the command unit for controlling and/or reading the device,
the backbone cable comprising a number of cables of a standard length, each connected in an end-to-end relationship, a number of electrical junctions for the interconnection of the cables, and a separate cable removable connecting each device to the junction.

18. A control system according to claim 17 wherein the cable comprises male connectors at each end.

19. A control system according to claim 17 wherein the cable comprises female connectors at each end.

20. A control system according to claim 17 wherein the junction is a three-way junction.

21. A control system according to claim 17 wherein the junction is a two-way junction.

22. A control system according to claim 17 wherein the junction includes a modem.

23. A control system according to claim 14 wherein the junction is a termination junction.

ABSTRACT

The invention relates to a control system for a subsea installation based on CAN bus technology. A single cable forms a backbone for transmitting signals and/or power from a central control unit to a number of devices or sensors on the installation. Terminals are attached to the cable at intervals, allowing devices to be plugged in while the system is operable. A termination may also include repeaters or amplifiers for transmitting signals over longer distances.

Fig. 2.

2004 -02- 20

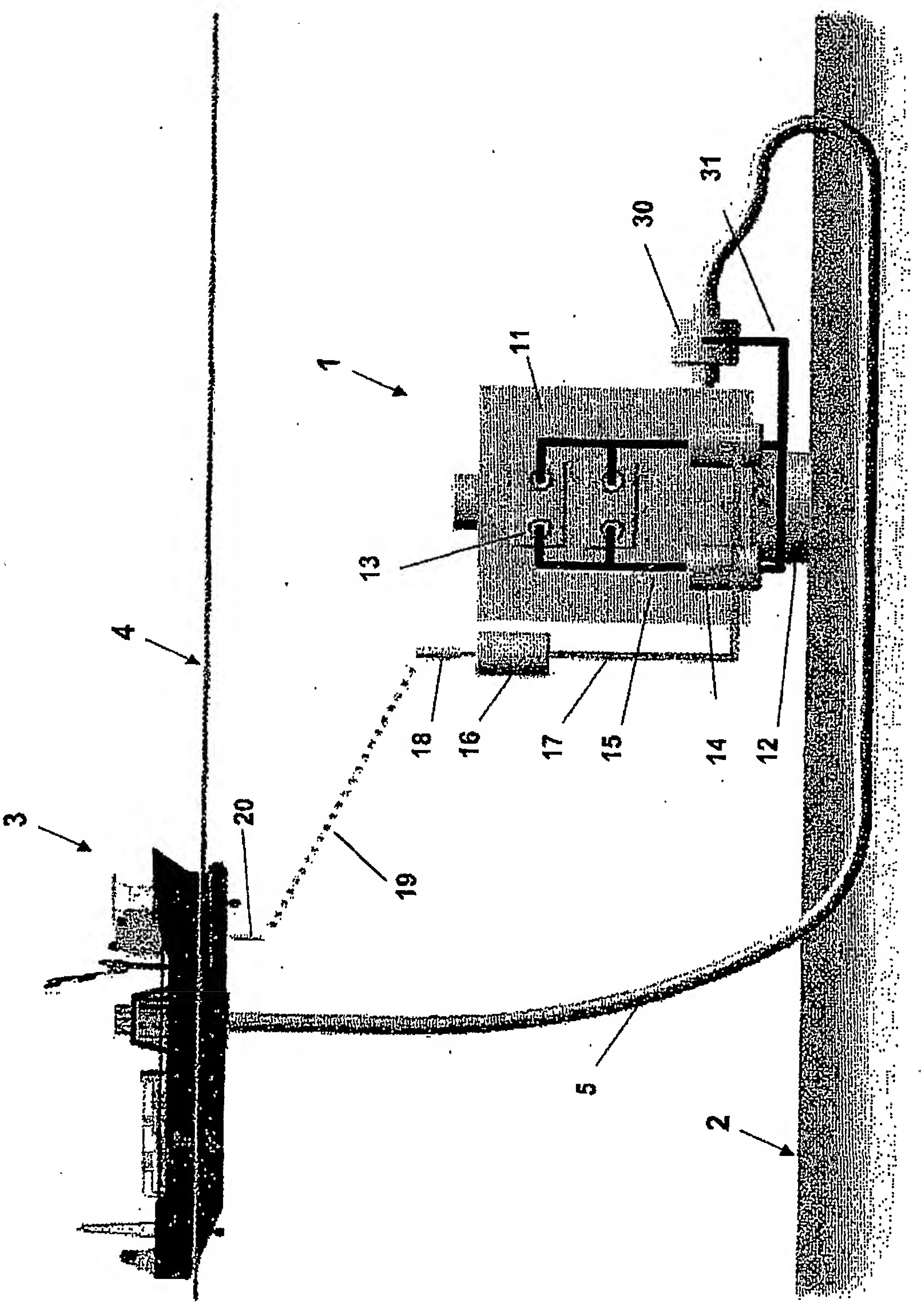

Fig. 1

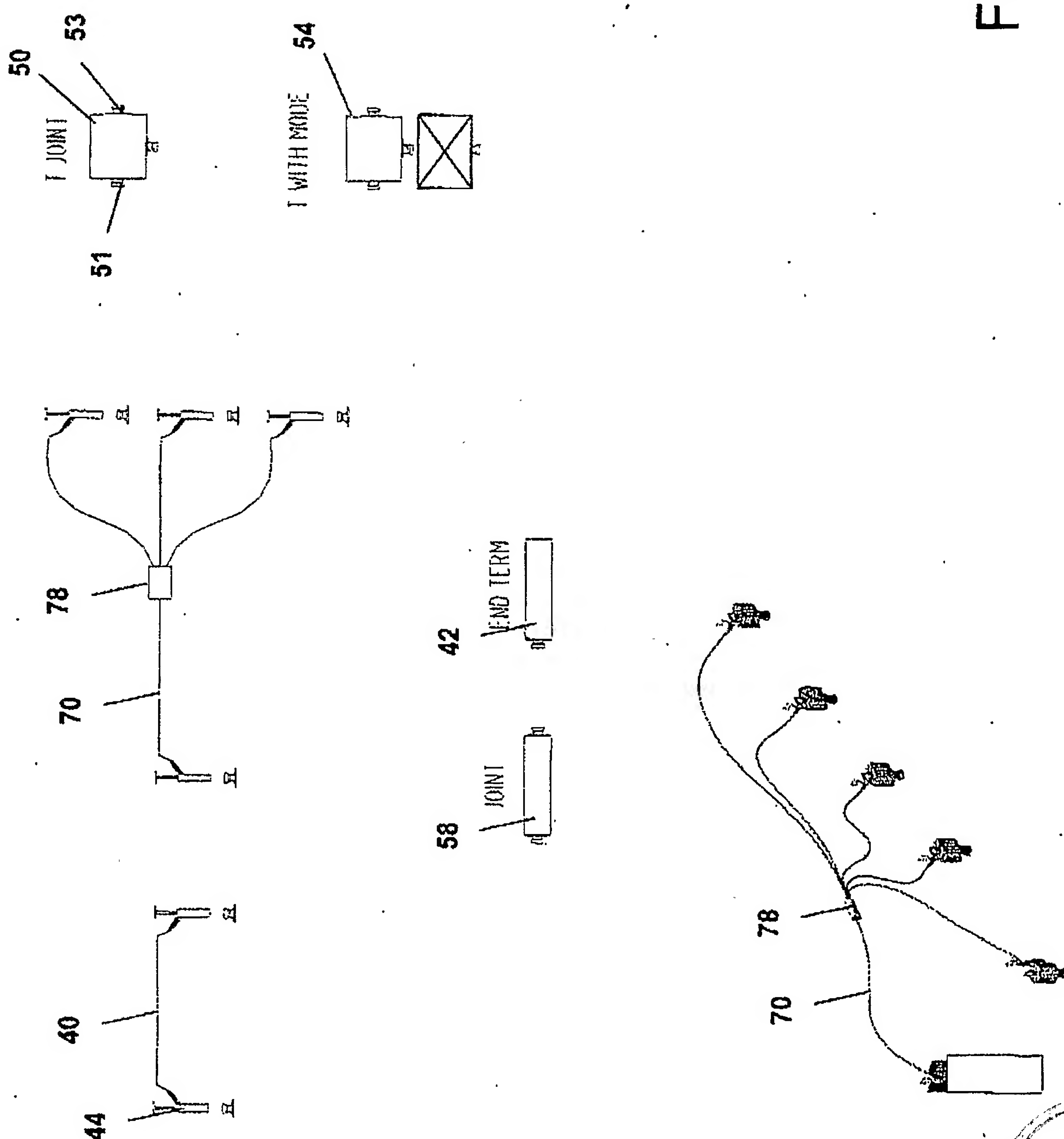
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Fig. 2

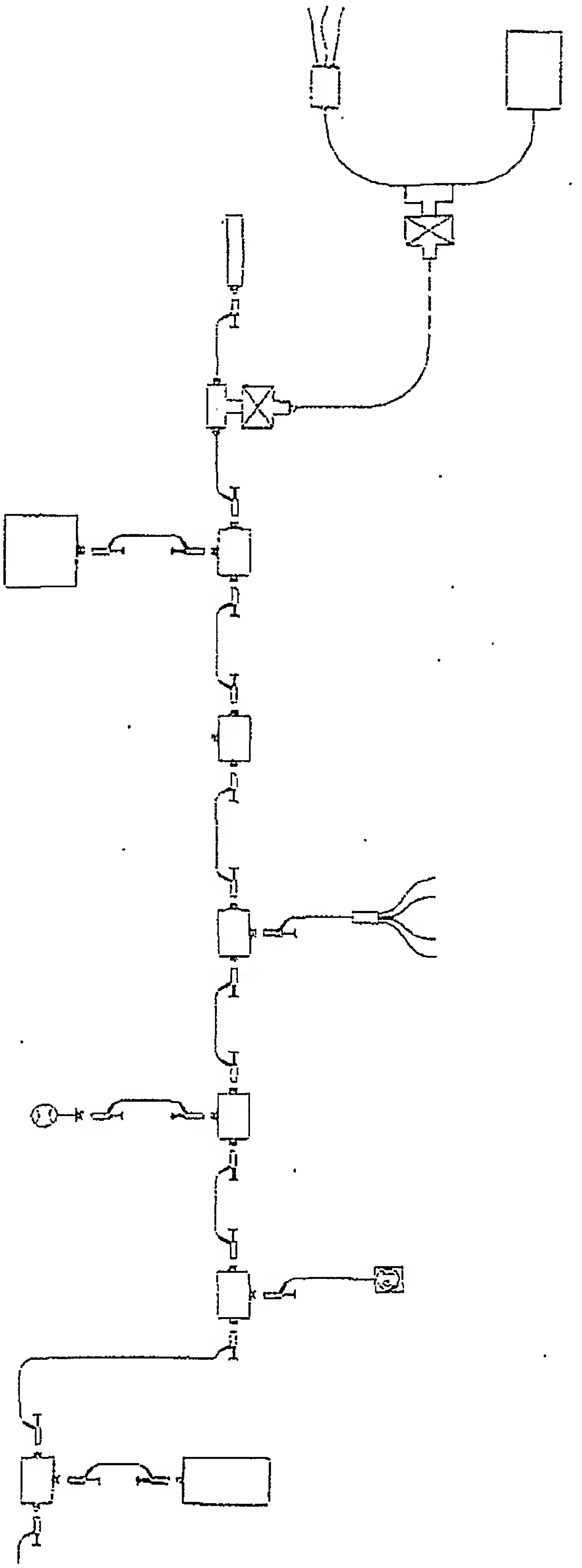

Fig. 3

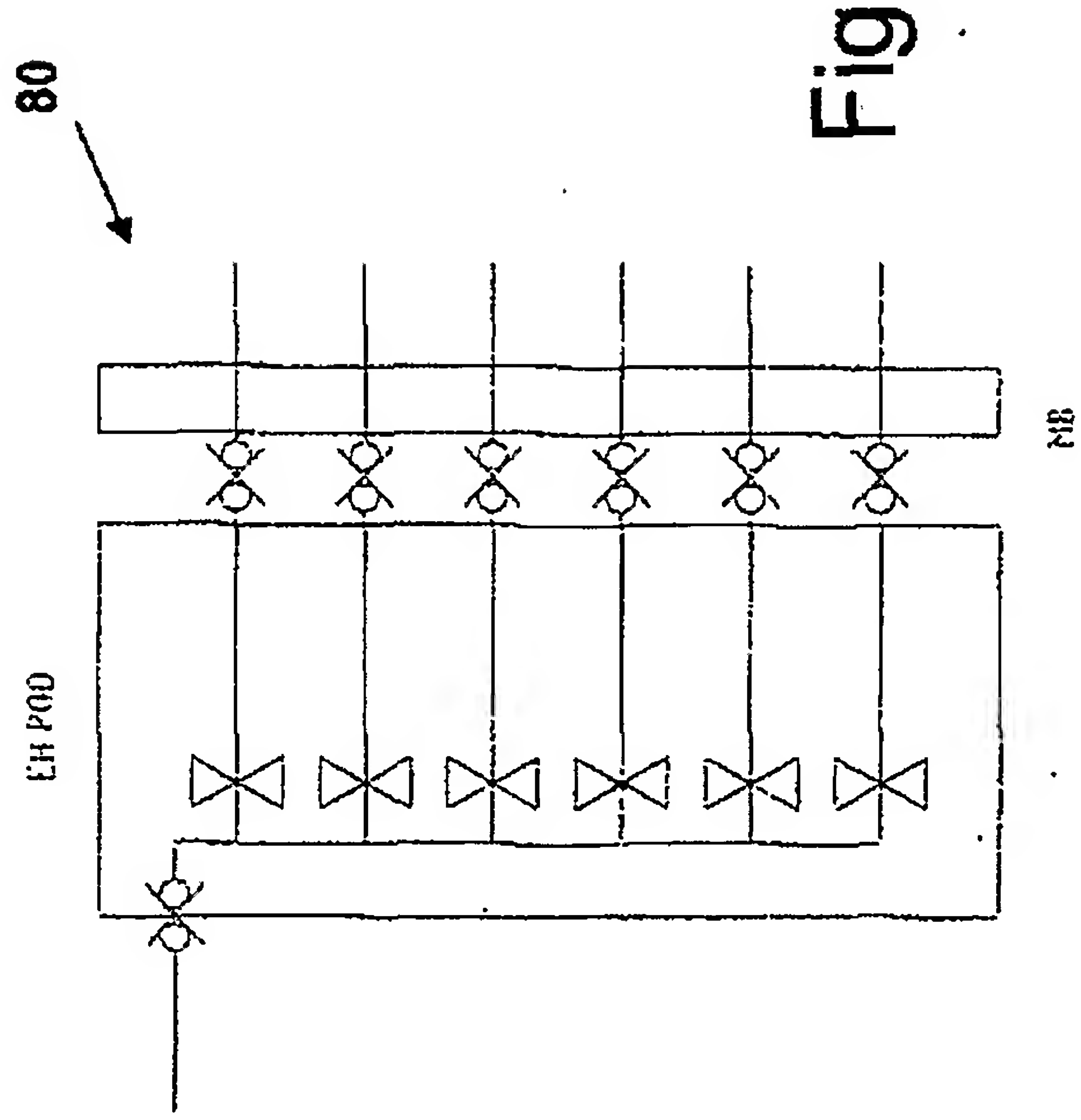

Fig. 2b

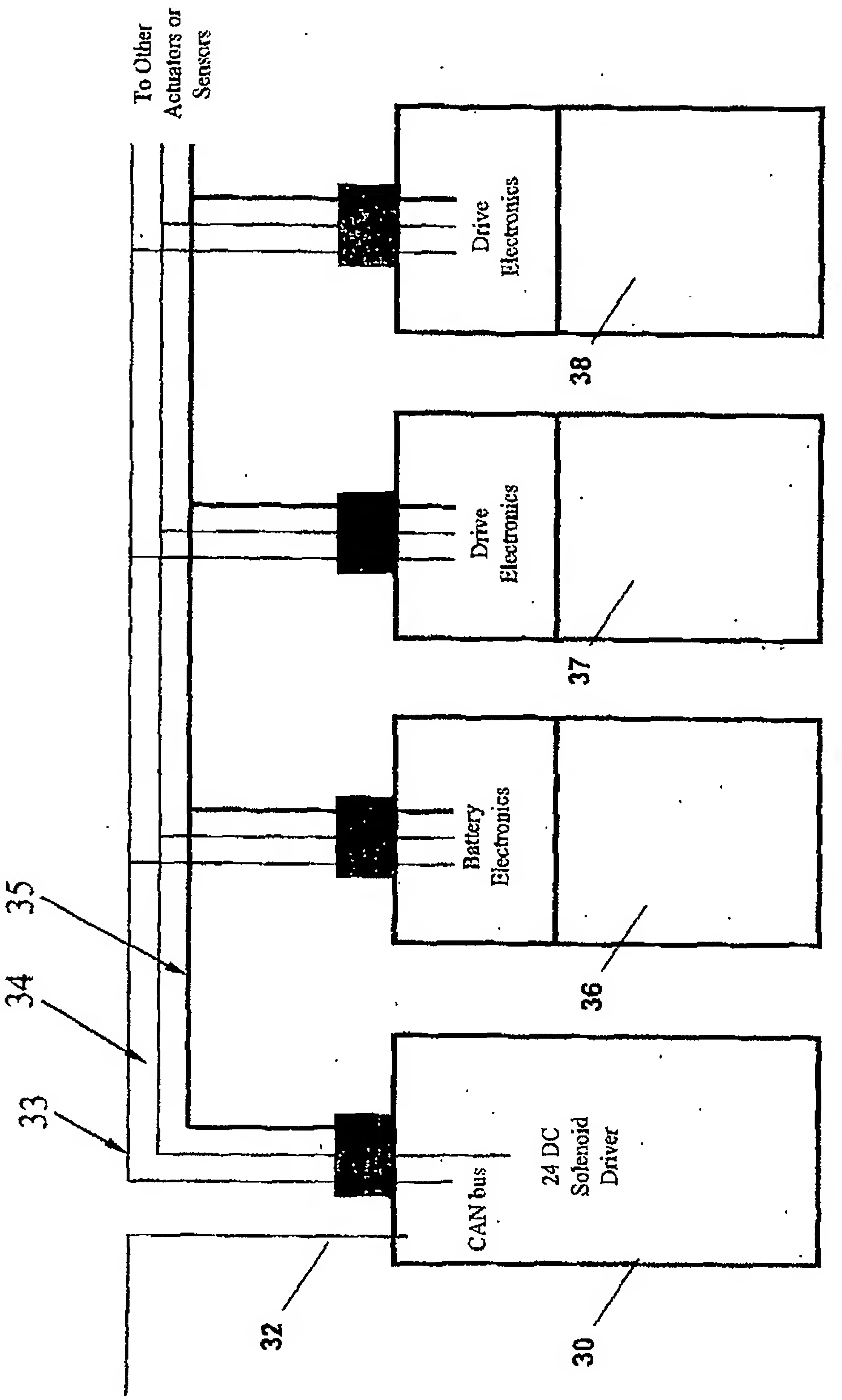
To Other Actuators or Sensors
Drive Electronics
38
Drive Electronics
37
Battery Electronics
36
35
34
33
CAN bus
24 DC Solenoid Driver
32
30

Fig. 4

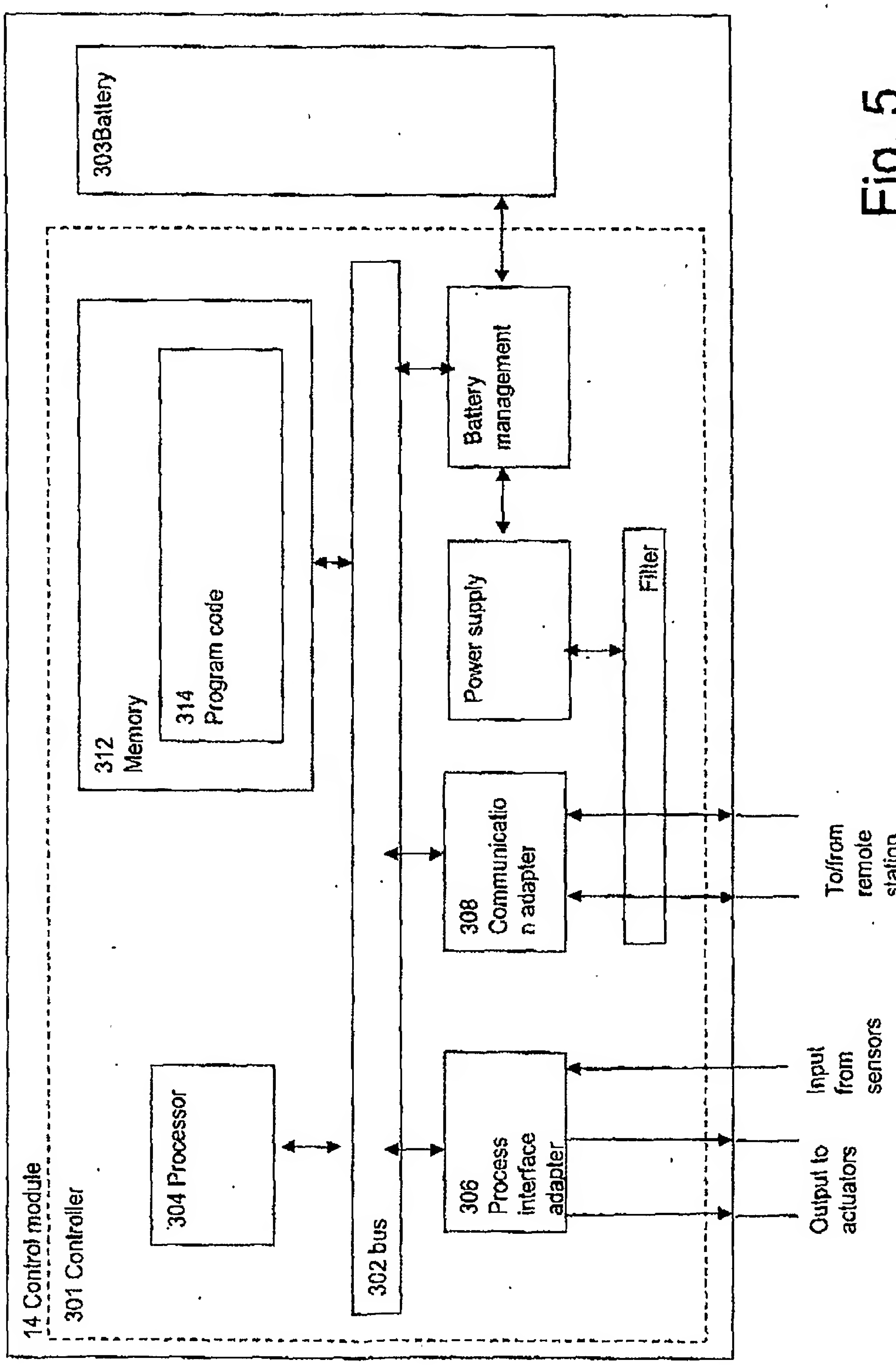
303Battery
14 Control module
301 Controller
312
Memory
314
Program code
304 Processor
302 bus
Battery
management
Power supply
Filter
308
Communicatio
n adapter
306
Process
interface
adapter
To/from
remote
station
Input
from
sensors
Output to
actuators

Fig. 5